

**The University of Burdwan**  
**Syllabus for B.Sc. Honours**  
**(1+1+1 Pattern)**  
**in**  
**Statistics**  
**with effect from 2014-2015**

**Part I Examination : Total marks = 200**

**Theoretical**

**150 marks**

**Paper I :**

**75 marks**

Group A : Descriptive Statistics

( 50 marks )

Group B : Linear Algebra

( 25 marks )

**Paper II :**

**75 marks**

Group A : Probability I

( 50 marks )

Group B : Population Statistics

( 25 marks )

**Practical**

**50 marks**

**Practical I using scientific calculator**

Based on topics in papers I and II

(40 marks)

Viva Voce

(5 marks)

Practical Notebook

(5 marks)

**Part II Examination: Total marks = 200**

**Theoretical**

**150 marks**

**Paper III:**

**100 marks**

Group A : Mathematical Methods and Probability II (50 marks)

Group B: Sampling Distributions and Statistical Inference I (50 marks)

**Paper IV:**

**50 marks**

Official Statistics, Economic Statistics & Statistical Quality Control (50 marks)

**Practical**

**50 marks**

**Practical II:** Based on topics from Paper III and IV (40 marks)

Viva Voce: (5 marks)

Practical Notebook: (5 marks)

**Part III Examination : Total marks = 400**

**Theoretical**

**200 marks**

**Paper V :**

**100 marks**

Group A: Multivariate Analysis and Large Sample Theory (50 marks)

Group B: Statistical Inference II & Analysis of variation (50 marks)

**Paper VI :**

**100 marks**

Group A : Sample Survey ( 35 marks )

Group B : Design of Experiments ( 40 marks )

Group C: Time Series ( 25 marks )

**Practical**

**200 marks**

**Practical III:** Based on topics in Paper V and Paper VI Group C (40 marks)

**Practical IV:** Based on topics in Paper VI excluding Group C (40 marks)

**Practical V:** Computer Programming C (40 marks)

**Practical VI:** Computation and Data Analysis with the help of Use of Statistical Software (40 marks)

Viva Voce: (20 marks)

Practical Notebook: (20 marks)

## Detailed Syllabus

### Part I

#### Paper I

**(75 marks)**

#### **Group A**

**(50 marks)**

#### **Descriptive Statistics**

Introduction: Nature of Statistics, Uses of Statistics, Statistics in relation to other disciplines, Abuses of Statistics. (2L)

Types of Data: Concepts of population and sample, quantitative and qualitative data, cross-sectional and time-series data, discrete and continuous data, different types of scales. (3L)

Collection and Scrutiny of Data: Primary data—designing a questionnaire and a schedule, checking its consistency. Secondary data— its major sources. Observational studies- Complete enumeration and sample surveys, scrutiny of data for internal consistency and detection of errors in recording, ideas of cross-validation. Controlled experiments, (3L)

Presentation of data: Construction of Tables with one or more factors of classification, diagrammatic representations, frequency distributions and cumulative frequency distributions and their graphical representations, stem and leaf displays. (4L)

Univariate data – Ideas and different measures of location, dispersion, relative dispersion, moments, skewness and kurtosis, Quantiles and measures based on them. Box Plot. Outlier Detection. (13L)

Bivariate data— scatter diagram, correlation coefficient and its properties, Correlation ratio, Correlation Index, Concept of Regression, Principles of least squares, Fitting of polynomial and exponential curves. Intraclass correlation, Rank correlation – Spearman's and Kendall's measures. (17L)

Analysis of Categorical Data: Consistency of data, independence and association of attributes, measures of association—Pearson's and Yule's measures, Goodman-Kruskal's  $\gamma$ . Odds Ratio. Fitting of logit model through least squares. (8L)

#### ***References:***

1. Goon A.M., Gupta M. K., Dasgupta B. (1998): Fundamentals of Statistics (V-1), World Press
2. Yule G.U & Kendall M.G. (1950): An Introduction to the Theory of Statistics, C.Griffin
3. Snedecor & Cochran (1967): Statistical Methods (6<sup>th</sup>ed), Iowa State Univ. Press
4. Croxton F.E., Cowden D.J. & Klein (1969): Applied General Statistics, Prentice Hall
5. Wallis F.E. & Roberts H.V. (1957): Statistics- a new approach, Methuen
6. Tukey J.W. (1977): Exploratory Data Analysis, Addison-Wesley Publishing Co.
7. Lewis-Beck M.S. (ed.) (1993) : Regression Analysis, Sage Publications
8. A. Agresti (1984): Analysis of Ordinal Categorical Data
9. Kendall M.G. & Stuart A. (1966): Advanced Theory of Statistics (Vols 1 & 2)

**Group B****(25 marks)****Linear Algebra**

Vector spaces over real field, Basis and dimension of a vector space, Orthogonal vectors, Gram-Schmidt Orthogonalization. (7L)

Linear transformation and Matrices, Matrix operations, Elementary matrices and their uses, Rank of a matrix and related results, Inverse of a matrix, Determinants, the Sweep-out and the Pivotal Condensation methods, Characteristic roots and vectors, Quadratic forms– classification and canonical reduction.

(16L)

Systems of Linear Equations: Homogeneous and Non-homogeneous systems– Conditions for solvability. (2L)

**References:**

1. Hadley G. (1995): Linear Algebra, Addison Wesley/ Narosa
2. Rao A.R. & Bhimasankaran P. (1996): Linear Algebra
3. Searle S.R. (1982): Matrix Algebra– useful for Statistics, John Wiley
4. Rao C.R. (1974): Linear Statistical Inference & its Applications, Wiley Eastern
5. Hoffman K. & Kunze R. (2001): Linear Algebra
6. Goon A.M. (1988): Vectors and Matrices

**Paper II****(75 marks)****Group A****(50 marks)****Probability I**

Random Experiment: Trial, Sample point, Sample space, Different types of events. (5L)

Definition of probability: Classical and relative-frequency approaches to probability, Kolmogorov's Axiomatic definition (discussion on discrete space only), limitations of Classical definition. Probability of union and intersection of events, Probability of occurrence of exactly  $m$  and at least  $m$  events out of  $n$  events. Conditional probability, Bayes' Theorem and Independence of events and its applications. Examples based on classical approach and repeated trials (20L)

Random Variables: Definition of discrete and continuous random variables, cumulative distribution function (c.d.f.) and its properties (with proof), probability mass function (p.m.f.) and probability density function (p.d.f.), Expectation and Moments, Dispersion, Skewness, Kurtosis, Quantiles (7L)

The c.d.f., p.m.f. and p.d.f. in bivariate case. Marginal and Conditional distributions, Independence, Conditional Expectation, Correlation and Regression. Theorems on expectations of sum and product of random variables. (15L)

Probability Inequalities: Markov's & Chebyshev's inequalities. (3L)

**References:**

1. Chung K.L. (1983): Elementary Probability Theory with Stochastic Process, Springer / Narosa
2. Feller W. (1968): An Introduction to Probability Theory & its Applications, John Wiley
3. Goon A.M., Gupta M.K. & Dasgupta B. (1994): An Outline of Statistical Theory (Vol-1), World Press
4. Rohatgi V.K. (1984): An Intro. to Probability Theory & Math. Statistics, John Wiley

5. Hoel P.J., Port S.C. & Stone C.J. ( ): Introduction to Probability Theory (Vol-1), Mifflin & UBS
6. Cramer H. (1954): The Elements of Probability Theory, John Wiley
7. Parzen E. (1972): Modern Probability Theory and its Applications, John Wiley
8. Uspensky J.V. (1937): Introduction to Mathematical Probability, McGraw Hill
9. Cacoullos T. (1973): Exercises in Probability. Narosa
10. Rahman N.A. (1983): Practical Exercises in Probability and Statistics, Griffen
11. Pitman J. (1993): Probability, Narosa
12. Stirzaker D. (1994): Elementary Probability, Cambridge University Press
13. Chandra T.K. & Chatterjee D. (2001): A First Course in Probability, Narosa
14. Bhat B.R. (1999): Modern Probability Theory, New Age International

## Group B

(25 marks)

### Population Statistics

Introduction: Sources of Population Data– Census data, Registration data and the errors in such data. Rates and ratios of vital events. (2L)

Measurements of Mortality: Crude death rate, specific death rate, standardized death rate, case fatality rate and cause of death rate, Infant mortality rate, Neonatal and Perinatal mortality rates (6L)

Life tables: Descriptions of Complete and Abridged Life Tables and their uses, Cohort vs. Current Life Tables, Stable population and Stationary population, Construction of complete life table using population and death statistics. (5L)

Measurements of Fertility: Crude Birth Rate, General Fertility Rate, Age Specific Fertility Rate, Total Fertility Rate. (4L)

Measurement of Population Growth: Crude Rate of Natural Increase and Vital Index, Gross and Net Reproduction Rates. (3L)

Population Estimation, Projection and Forecasting: Use of A.P. and G.P. methods for population estimates, Fitting of Logistic curve for population forecasting using Rhode's method. (5L)

### **References:**

1. Goon AM, Gupta MK, Dasgupta B (2001): Fundamentals of Statistics (V-2), World Press
2. Spiegelman M. (1980): Introduction to Demography, Harvard University Press
3. Cox P.R. (1976): Demography
4. Biswas S. (1988): Stochastic Processes in Demography and Applications
5. Mishra B.D. (1980): An Introduction to the Study of Population, South Asian Pub.
6. Keyfitz. N and Caswell. H (2005): Applied Mathematical Demography (3<sup>rd</sup> edition), Springer

**Part II Examination : Total marks = 200**

**Paper III**

**(100 marks)**

**Group A**

**(50 marks)**

**Mathematical Methods (25 marks)**

***Numerical Methods (15 marks):***

Approximation of numbers and functions, Absolute and Relative errors. (1L)

Interpolation: Polynomial approximation, Difference Table, Newton's Forward and Backward interpolation formulae and Lagrange's general interpolation formula, Error terms (5L)

Numerical Differentiation and its applications. (2L)

Numerical Integration: Trapezoidal and Simpson's  $\frac{1}{3}$  rules. (2L)

Numerical solution of equations: method of fixed point iteration and Newton-Raphson method in one unknown, Conditions of convergence, rates of convergence. Extension of the iteration method to two unknowns (without convergence) (4L)

Stirling's approximation to factorial n. (1L)

***Calculus of several variables (10marks):***

Maxima and minima for functions of several variables, Constrained maximization and minimization – use of Lagrange multiplier, Multiple integrals, Transformation of Variables and Jacobian, Polar and Orthogonal transformations (10L)

***References:***

1. Scarborough J.B. (1958): Numerical Mathematical Analysis, Oxford Univ. Press
2. Atkinson K. (1985): Elementary Numerical Analysis
3. Sastry S.S. (1998): Intriductory Methods of Numerical Analysis
4. Hildebrand F.B. (1974): Introduction to Numerical Analysis, Tata McGraw-Hill
5. Apostol T.M. (1985): Mathematical Analysis, Narosa
6. Apostol T.M. (1968): Calculus (Vols 1 & 2)
7. Goldberg R.R. (1953): Methods of Real Analysis, Oxford & IBH Pub. Co.
8. Widder D.V. (1994): Advanced Calculus
9. Piskunov N. (1977): Calculus (Vols 1 & 2)
10. Malik S.C. & Arora S. (1991): Mathematical Analysis

## Probability II (25 marks)

Generating Functions: Probability generating function and moment generating function in the univariate and bivariate cases. (3L)

Univariate Discrete Distributions: Uniform, Bernoulli, Hypergeometric, Binomial, Poisson, Negative Binomial, Geometric distributions and their properties. (7L)

Univariate Continuous Distributions: Rectangular, Normal (Normal approximation of the Poisson distribution), Cauchy, Gamma, Beta, Exponential, Laplace, Logistic, Pareto, Log-normal distributions and their properties. Truncated distributions (Binomial, Poisson and Normal). (9L)

Scaling methods: Z, Percentile, Thurstone, Equivalent scaling procedures (3L)

Bivariate Normal Distribution and its properties. (3L)

### References:

1. Chung K.L. (1983): Elementary Probability Theory with Stochastic Process, Springer / Narosa
2. Feller W. (1968): An Introduction to Probability Theory & its Applications, John Wiley
3. Goon A.M., Gupta M.K. & Dasgupta B. (1994): An Outline of Statistical Theory (Vol-1), World Press
4. Rohatgi V.K. (1984): An Intro. to Probability Theory & Math. Statistics, John Wiley
5. Hoel P.J., Port S.C. & Stone C.J. ( ): Introduction to Probability Theory (Vol-1), Mifflin & UBS
6. Cramer H. (1954): The Elements of Probability Theory, John Wiley
7. Parzen E. (1972): Modern Probability Theory and its Applications, John Wiley
8. Uspeky J.V. (1937): Introduction to Mathematical Probability, McGraw Hill
9. Cacoullos T. (1973): Exercises in Probability. Narosa
10. Rahman N.A. (1983): Practical Exercises in Probability and Statistics, Griffen
11. Pitman J. (1993): Probability, Narosa
12. Stirzaker D. (1994): Elementary Probability, Cambridge University Press
13. Chandra T.K. & Chatterjee D. (2001): A First Course in Probability, Narosa
14. Bhat B.R. (1999): Modern Probability Theory, New Age International
15. Goon A.M., Gupta M.K. & Dasgupta B. (1994): Fundamentals of Statistics (Vol-II), World Press

## Group B (50 marks)

### Sampling Distribution (25 marks)

Introduction: Concepts of Random Sampling, Statistics and Sampling Distributions of Statistics. Illustrations using different distributions, reproductive properties of the distributions. (7L)

Some Standard Sampling Distributions:  $\chi^2$  distribution, distributions of the mean and variance of a random sample from a normal population, t and F distributions. Distributions of means, variances and correlation coefficient (null case) of a random sample from a bivariate normal population, (13L)

Distributions of Order Statistics and Sample Range. (5L)

### References:

1. Goon A.M., Gupta M.K. & Dasgupta B. (1994): An Outline of Statistical Theory (Vol-1), World Press
2. Johnson, N.I. & Kotz S. (1970): Distributions in Statistics, John Wiley
3. Ross S.M. (1972): Introduction to Probability Models, Academic Press
4. Mood A.M., Graybill F. & Boes D.C. (1974): An Introduction to the Theory of Statistics (3<sup>rd</sup>ed), McGraw Hill
5. Rao C.R. (1952): Advanced Statistical Methods in Biometric Research, John Wiley
6. Hogg R.V. & Craig A.T. (1978): Introduction to Mathematical Statistics
7. Rohatgi V.K. (1984): An Introduction to Probability Theory & Mathematical Statistics, John Wiley

8. Stuart G & Ord J.K. (1991): Advanced Theory of Statistics (Vol 2), Charles Griffin
9. Goon A. M., Gupta M. K. and Dasgupta B. (1997): Fundamentals of Statistics (V-1), World Press
10. Bhattacharya GK & Johnson R. A. (1977): Concepts & Methods of Statistics, John Wiley

***Statistical Inference I (25 marks)***

Idea of Inference - Point & Interval Estimations and Testing of Hypothesis (2L)

Point estimation: Sufficient Statistic and Factorization Theorem (Discrete case only), Requirements of a good estimator– notions of Mean Square Error, Unbiasedness, Consistency, Efficiency (asymptotic) Minimum Variance unbiasedness and Best Linear Unbiasedness, Properties of minimum variance, unbiased estimators, consistent estimators and asymptotic efficiency, Cramer-Rao lower bound, Rao-Blackwell Theorem. (17L)

Methods of Estimation– Moment, Least-square, Maximum Likelihood & Minimum  $\chi^2$  methods and their properties (excluding proofs of large sample properties). (6L)

***References:***

1. Goon A.M., Gupta M.K. & Dasgupta B. (1994): An Outline of Statistical Theory (Vol-2), World Press
2. Johnson, N.I. & Kotz S. (1970): Distributions in Statistics, John Wiley
3. Ross S.M. (1972): Introduction to Probability Models, Academic Press
4. Mood A.M., Graybill F. & Boes D.C. (1974): An Introduction to the Theory of Statistics (3<sup>rd</sup> ed), McGraw Hill
5. Rao C.R. (1952): Advanced Statistical Methods in Biometric Research, John Wiley
6. Hogg R.V. & Craig A.T. (1978): Introduction to Mathematical Statistics
7. Rohatgi V.K. (1984): An Introduction to Probability Theory & Mathematical Statistics, John Wiley
8. Stuart G & Ord J.K. (1991): Advanced Theory of Statistics (Vol 2), Charles Griffin
9. Goon A. M., Gupta M. K. and Dasgupta B. (1997): Fundamentals of Statistics (V-1), World Press
10. Bhattacharya GK & Johnson R. A. (1977): Concepts & Methods of Statistics, John Wiley

**Paper IV**

**(50 marks)**

**Official Statistics and Economic Statistics, and Statistical Quality Control (50 marks)**

***Official Statistics (Marks 10)***

The Statistical system in India: The Central and State Government organizations, the functions of the Central Statistical Office (CSO), the National Sample Survey Office (NSSO)

(4L)

National Income statistics: Income, expenditure and production approaches. Their applications in various sectors in India (6L)

***Economic Statistics (Marks 15)***

Index Numbers: Price, Quantity and Value indices. (1L)

Price Index Numbers: Construction, Uses, Limitations, Tests for index numbers, Various formulae and their comparisons, Chain Index Number. (7L)

Some Important Indices: Consumer Price Index, Wholesale Price Index and Index of Industrial Production – methods of construction and uses. (3L)

Measurement of income inequality: Gini's coefficient, Lorenz curves, Application of Pareto and Lognormal as income distributions (4L)

***Statistical Quality Control (Marks 25)***

Introduction: Concepts of Quality, and Quality Control, Process Control and Product Control (5L)

Process Control: Control Charts and their uses, Choice of Subgroup sizes, Construction of control charts by attributes (np, p,c) (including unequal subgroup size) and variables ( $\bar{X}, R$ ), ( $\bar{X}, s$ ). Interpretation of non-random patterns of points. (10L)

Product Control: Producer's Risk, Consumer's Risk, Acceptance Sampling Plan, Single and Double sampling plans by attributes, their OC, ASN (and ATI), LTPD and AOQL. Single sampling plan for inspection by variables (one-sided specification, known and unknown  $\sigma$  cases), Use of IS plans and tables (10L)

***References:***

1. C.S.O. (1984) : Statistical System in India
2. Goon A. M., Gupta M. K., and Dasgupta. B. (2001): Fundamentals of Statistics (V-2), World Press
3. Yule G.U. & Kendall M.G. (1953): An Introduction to the Theory of Statistics, C. Griffin
4. Kendall M.G. & Stuart A. (1966): Advanced Theory of Statistics (Vol 3), C.Griffin
5. Croxton F.E., Cowden D.J. & Klein (1969): Applied General Statistics, Prentice Hall
6. Mudgett B.D. (1951): Index Numbers, John Wiley
7. Allen R.G.D. (1975): Index Numbers in Theory and Practice, Macmillan
8. Mukhopadhyay P. (1999): Applied Statistics
9. Johnston J. & Dinardo J. (1997): Econometric Methods, McGraw Hill
10. Nagar A.L. & Das R.K. (1976): Basic Statistics
11. 2. Duncan A.J. (1953): Quality Control and Industrial Statistics, Richard D Irwin
12. Cowden D.J. (1957): Statistical Methods in Quality Control, Prentice Hall
13. Grant E.L. & Leavenworth (1964): Statistical Quality Control, McGraw Hill
14. Bowley A.H. & Goode H.P. (1952): Sampling Inspection by Variables, McGraw Hill
15. Ekambaram S. K. (1960): The Statistical Basis of Quality Cont. Charts, Asia Publishing House
16. Montgomery D.C. (1985): Introduction to Statistical Quality control, John Wiley
17. IS2500 Part I and Part II
18. Bureau of Indian Standards (1994): Handbook on Statistical quality Control
19. Indian Standards Institution (1982): Manual on Basic Principles of Lot Sampling

**Part III Examination: Total marks = 200**

**Paper V**

**(100 marks)**

**Group A**

**(50 marks)**

***Multivariate Analysis (Marks 25)***

Multivariate data—multiple regression, multiple correlation and partial correlation—their properties and related results. (8L)

Random Vector: Probability mass and density functions, Distribution Function, Mean vector and Dispersion matrix, Marginal and Conditional Distributions, Ellipsoid of Concentration, Multiple Regression, Multiple Correlation, Partial Correlation. (9L)

Multivariate Distributions: Multinomial, Multivariate Normal distributions and their properties. (8L)

***References:***

1. Kendall M.G. & Stuart A. (1966): Advanced Theory of Statistics (Vol 3), C.Griffin
2. Anderson T.W. (1958): An Introduction to Multivariate Statistical Analysis, 3<sup>rd</sup> edition, Wiley inter science
3. Goon A.M., Gupta M.K. & Dasgupta B. (1994): An Outline of Statistical Theory (Volumes 1 & 2), World Press
4. Rohatgi V.K. (1984): An Introduction to Probability Theory & Math. Statistics, JohnWiley
5. Johnson, N.L. & Kotz S. (1970): Distributions in Statistics, John Wiley
6. Hogg R.V. & Craig A.T. (1978): Introduction to Mathematical Statistics
7. Rao C.R. (1974): Linear Statistical Inference and its Applications, John Wiley
8. Mukhopadhyay P. (1996): Mathematical Statistics
9. Johnson R. A. and Wichern, W(2001): Applied Multivariate Statistical Analysis, 5<sup>th</sup> edition, Prentice Hall

***Large Sample Theory (Marks 25)***

Convergence in Probability, Weak Law of Large Numbers and its applications, Convergence in Distribution, De Moivre Laplace limit theorem, Statement of Central Limit Theorem (i.i.d. case) & its applications. (8L)

Delta method, Derivation of large sample standard error of sample moments, standard deviation, coefficient of variation,  $b_1$  and  $b_2$  measures, and correlation coefficient and their uses in large sample tests under normality assumption, Large sample distribution of sample quantile (8L)

Transformations of Statistics to stabilize variance: derivation and use of  $\text{Sin}^{-1}$ , square root, logarithmic and z-transformations. (3L)

Large sample tests for binomial proportions, Poisson means (single and two independent samples cases) and correlation coefficients. (3L)

Large Sample distribution of Pearsonian  $\chi^2$ -statistic and its uses. Yate's correction in a 2x2 contingency table. (3L)

***References:***

1. Goon A.M., Gupta M.K. & Dasgupta B. (1994): An Outline of Statistical Theory (Vol-1 and 2), World Press
2. Serfling R.J. (1980): Approximation Theory of Mathematical Statistics, John Wiley
3. Chandra T.K. (1999): A First Course in Asymptotic Theory in Statistics, Narosa
4. Hogg R.V. & Craig A.T. (1978): Introduction to Mathematical Statistics

## Group B

(50 marks)

### ***Statistical Inference II (Marks 40)***

Elements of Hypothesis Testing: Null and Alternative hypotheses, Simple and Composite hypotheses, Critical Region, Type I and Type II Errors, Level of Significance and Size, p-value, Power (4L)

Tests of Significance related to a single Binomial proportion and Poisson parameter; two Binomial proportions and Poisson parameters; the mean(s) and variance(s) of a single univariate normal distribution, two independent normal distributions and a single bivariate normal distribution; regression and correlation coefficients of a single bivariate normal distribution, Combination of Probabilities in tests of significance (11L)

Theory of Hypothesis Testing: Most Powerful (MP), Uniformly Most Powerful (UMP), Randomized and Nonrandomized tests, Neyman-Pearson Fundamental Lemma (sufficiency part only), and its use in the construction of MP and UMP tests (single parameter with range independent of the parameters), Uniformly Most Powerful Unbiased (UMPU) tests (definition only). (9L)

Likelihood Ratio tests and its applications to tests for the equality of means and variances of several normal populations. (5L)

Interval Estimation: Confidence intervals, Concepts of Uniformly Most Accurate (UMA) confidence sets, relationship with tests of hypotheses. (3L)

Nonparametric Methods: Sign test, Mann-Whitney test, Run test, Test of randomness, Confidence limits for Quantiles based on Sign test statistic. (8L)

### ***Analysis of Variance (ANOVA) (Marks 10)***

Introduction: Heterogeneity and Analysis of Variance and Covariance, Linear Hypothesis, Orthogonal splitting of total variation, Selection of Valid Error. (3L)

Applications of the ANOVA technique to: one-way classified data, two-way classified data with equal number of observations per cell, testing simple regression coefficients, tests for parallelism and identity, correlation ratio, linearity of simple regression, multiple correlation and partial correlation coefficients. (7L)

### ***References:***

1. Goon A.M., Gupta M.K. & Dasgupta B. (1994): An Outline of Statistical Theory(Vol-2), World Press
2. Mood A.M., Graybill F. & Boes D.C. (1974): An Introduction to the Theory of Statistics (3<sup>rd</sup>ed), McGraw Hill
3. Rao C.R. (1952): Advanced Statistical Methods in Biometric Research, John Wiley
4. Hogg R.V. & Craig A.T. (1978): Introduction to Mathematical Statistics
5. Rohatgi V.K. (1984): An Introduction to Probability Theory & Mathematical Statistics, John Wiley
6. Stuart G & Ord J.K. (1991): Advanced Theory of Statistics (Vol 2), Charles Griffin
7. Goon A. M., Gupta M. K. and Dasgupta B. (1997): Fundamentals of Statistics (V-1 and 2), World Press
8. Bhattacharya GK & Johnson R. A. (1977): Concepts & Methods of Statistics, John Wiley
9. Scheffe H. (1959): The Analysis of Variance, John Wiley

## **Paper VI**

**(100 marks)**

### **Group A**

**(35 marks)**

#### ***Sample Survey***

Introduction: Concepts of Finite Population and Sample, Need for Sampling, Complete Enumeration and Sample Surveys. (2L)

General Ideas: Planning and execution of sample surveys, analysis of data and reporting, Biases and Errors. Judgment and probability sampling schemes. Tables of Random Numbers and their uses (3L)

Simple Random Sampling with and without replacement, Determination of sample size in simple random sampling. (6L)

Stratified random sampling, Linear and Circular Systematic Sampling, Cluster sampling, Two-stage (with equal-sized first stage units) sampling with equal selection probabilities at each stage. Associated unbiased estimators of population total, mean, and proportion, their variances and unbiased variance estimators. Allocation problem in stratified random sampling and optimum choice of sampling and sub-sampling fractions in two - stage sampling, Interpenetrating sub-sampling technique for unbiased variance estimation in systematic sampling (18L)

Ratio and Regression methods of estimation in simple random sampling. Double sampling for ratio and regression estimators. (6L)

#### ***References:***

1. Goon A. M. ,Gupta M. K., Dasgupta B.(2001):Fundamentals of Statistics (V-2),World Press
2. Murthy M.N. (1977): Sampling Theory and Methods, Statistical Pub. Soc., Calcutta
3. Des Raj & Chandhok P.(1998): Sample Survey Theory, Narosa Publishing House
4. Cochran W.G. (1984): Sampling Techniques (3<sup>rd</sup> edition), Wiley Eastern
5. Mukhopadhyay P. (1998): Theory and Methods of Survey Sampling, Prentice Hall
6. Sukhatme P.V. & Sukhatme B.V. (1970): Sampling Theory of Surveys with, Asia Publishing House
7. Sampathy S. (2001): Sampling Theory and Methods, Narosa
8. NSSO Publications

### **Group B**

**(40 marks)**

#### ***Design of Experiments***

Principles of experimental design: Randomization, Replication and Local Control, Uniformity trials, Shapes and Sizes of Plots and Blocks. (4L)

Standard Designs and their Analyses: Completely Randomized Design (CRD), Randomized Block Design (RBD), Latin Square Design (LSD), comparison of efficiencies. Applications of the techniques of ANOVA to the analysis of the above designs. (11L)

Split Plot Design and Strip arrangements. (3L)

Factorial Experiments: 2<sup>n</sup> experiments, Advantages, Total and Partial Confounding, Analysis (11L)

Missing Plot Technique: Analysis with one missing plot in a RBD and in a LSD. (5L)

Analysis of Covariance (ANCOVA): Application of the ANCOVA technique to one-way classified data and to two-way classified data with equal number of observations per cell, use in the control of error in CRD, RBD and LSD. (6L)

**References:**

1. Kempthorne O. (1965): The Design and Analysis of Experiments, Wiley Eastern
2. Das M.N. & Giri N.C. (1986) : Design and Analysis of Experiments. (2<sup>nd</sup> edition), Wiley Eastern
3. Montgomery D.C. (1976): Design and Analysis of Experiments, John Wiley
4. Cochran W.G. & Cox G.M. (1957): Experimental Designs, John Wiley
5. Federer W.T. (1975): Experimental Designs– Theory and Application, Oxford & IBH
6. Mukhopadhyay P. (1999): Applied Statistics

**Group C**

**(25 marks)**

**Time Series Analysis**

Introduction: Examples of time series from various fields, Components of a times series, Additive and Multiplicative models. (2L)

Trend and Seasonal Components: Estimation of trend by linear filtering (simple and weighted moving-averages) and curve fitting (polynomial, exponential and Gompertz), Detrending. Estimation of seasonal component by ratio- to- moving-average method, ratio to trend method, Deseasonalization. (10L)

Stationary Time series: Weak stationarity, Autocorrelation Function and Correlogram (4L)

Some Special Processes: Moving-average (MA) process and Autoregressive (AR) process of orders one and two, Estimation of the parameters of AR(1) and AR(2) – Yule-Walker equations (7L)

Exponential smoothing method of forecasting (2L)

**References:**

1. Kendall M.G. (1976): Time Series, Charles Griffin
2. Chatfield C. (1980): The Analysis of Time Series –An Introduction, Chapman & Hall
3. Mukhopadhyay P. (1999): Applied Statistics
4. Johnston J. & Dinardo J. (1997): Econometric Methods, McGraw Hill

**Practical V**

**Computer Programming C**

Computer Programming:

1. Input-output statements
2. Operator-relational and logical, conditional operator
3. Library functions
4. Data type
5. Decision making and branching-If, If-else, Nesting of if statement, goto statement
6. Arrays
7. Use of Functions
8. File structure
9. Some selected C programs:

- (i) Selection and Bubble sort, Computation of quantiles, Computation of Spearman's rank correlation coefficient (no tie case)
- (ii) Fitting of Binomial and Poisson distributions
- (iii) Interpolation by Lagrange's formula.
- 10. Looping structure (control statement)–while, do while
- (iv) Numerical integration (Trapezoidal and Simpson's 1/3 rule) with convergence;
- (vi) Solution of numerical equations by Newton Raphson and iterative method (single variable);
- (vii) Addition, multiplication, transpose of matrices
- (viii) Trace, determinant and inverse of square matrices
- (ix) Generation of random samples from Normal, Chi-square, t and F distributions.

## **Practical VI:**

### ***Computation and Data Analysis with the help of Use of Statistical Software***

Computation and Data Analysis encompassing all topics taught in the three years. Uses may be made of all computational methods taught in the three years with analysis tool pack of EXCEL and modules of MINITAB